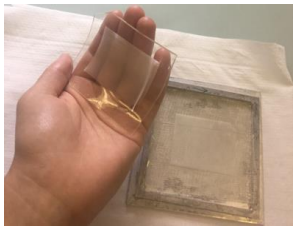
NANOTECHNOLOGY FOR SOLAR ENERGY CONVERSION

Group leader: Dr Andreas Schüler
Postdoctoral fellow: Dr André Kostro,
PhD students: Olivia Bouvard, Jing Gong, Anna Krammer, Djamel Mansour (FhG-ISE, Freiburg, Germany)
Research assistants: Luc Burnier, Alexandre Diévart, Jérémy Charmillot



Due to their fascinating optical and electronical properties, nanometric scaled structures play an important role in solar energy conversion. The research group "Nanotechnology for Solar Energy Conversions" develops and characterizes novel nanostructured materials for solar energy applications.

The nanocomposite coatings consist typically of dielectrics, semiconductors or metal nano-crystals embedded in a dielectric matrix.

Applications include antireflection coatings on solar collector glazing, coloured coatings with high solar transmittance for novel glazing of solar thermal facades, photoluminescent quantum dot solar concentrators for photo-voltaic energy conversion and optical selective absorber coatings for thermal solar collectors and thermoelectric power generation.

The research group carries out fundamental research on novel nanocomposite materials and thin film materials and promotes the introduction of novel solar technologies through upscaling of the corresponding innovative manufacturing processes. It has submitted and been granted several patents.

Published work relates to

- Coloured thermal collectors and PV modules for solar facades and solar roofing
- Nanostructured low refractive index materials on solar collector glazing
- Quantum dot solar concentrators for building integrated photovoltaics
- Durable selective absorber coatings for solar thermal collectors and electricity generation by concentrated solar power (CSP)
- Thermochromic films for smart solar energy applications
- Optical Microstructures for advanced architectural glazing
- Structured transparent low emissivity coatings with high microwave transmission

2017 Activities

Highlights of this year include:

- Major advances were made with respect to phase change properties in the field of thermochromic materials and microelectronics. The results were reported in Applied Physics and in Scientific Reports, among other, and a European patent was published.
- A PCT application was filed on a High Performance Solar Cooker and an grant was obtained for its further development. The development was a joint effort with the Urban systems group.
- The group advanced in the development of dry lithiation for all-solid-state electrochromic windows, which should considerably expand their lifetime and quality.
- The microwave transparent insulation glazing developed in a project with AGC-Vim and BLS was commissioned for 29 trains and other major train companies expressed their interest.
- The flagship Copenhagen International School building as well as several other iconic buildings were covered with colored solar pv cladding based on patented developments by this group.

Current Projects

Target 95 - Thermochromic coatings for overheating protection of solar thermal collectors - novel type of doping
Funding: Swiss Federal Office of Energy (SFOE)
Duration: 2015-2018
Overheating and stagnation of solar thermal collectors lead to water evaporation, glycol degradation and stresses as well as degradation of collector component materials. In this project, thermochromic coatings that exhibit a change in optical properties at critical temperatures are further developed. The effect of doping on the transition temperature is studied. Multi-layered coatings for maximised performance are developed, applications explored, and promising fields for market introduction identified.

Reduzierung des Heizenergiebedarfs von Bahnfahrzeugen durch verbesserte Wärmedämmung der Fahrzeughülle
Funding: Swiss Federal Office of Energy (SFOE)
Duration: 2017-2019
To reduce electricity consumption in rail transport, a large project with multiple partners including LESO-PB investigates all relevant aspects of vehicle envelopes. Based on Phase I of this project, which included the development of insulation glazing transparent to microwaves used in mobile networks (Windowave), a prototype train wagon is installed, monitored and compared to a reference train.

SCCER FEEB&D Phase II, Task 1.1.2 Glazing with dynamic solar heat gains
Funding: Commission for Technology and Innovation (CTI)
Duration: 2017-2020
Novel glazing with dynamic solar heat gains is developed applying two approaches: the development of light-redirecting microstructures that allow a clear view while providing seasonal thermal control and visual comfort and the development of nanostructured electrochromic materials with enhanced switching speed and durability.

High-performance solar cooker (Project in collaboration with Urban Systems group)
Funding: ENAC Enable-InnoSeed Program
Duration: 2017-18
In this project, a new, high-efficiency solar cooker is developed with the aim of market introduction. Its novelty resides in the combination of high thermal performance glazing with low-emissivity coating, high window-to-wall surface ratio, vacuum insulation and a foldable high reflectivity concentration system.

Selected 2017 publications

- Krammer A., Magrez A., Vitale W. A., Mocny P., Jeanneret P., Guibert E., Whitlow H. J ., Ionescu A. M ., Schueler A., Elevated transition temperature in Ge doped VO2 thin films, in Journal Of Applied Physics, vol. 122, num. 4, p.045304, 2017
- Bouvard O., Lanini M., Burnier L., Witte R., Cuttat B., Salvadè A., Schueler A., Structured transparent low emissivity coatings with high microwave transmission, in Applied Physics a Materials Science and Processing, vol. 123, num. 66, 2017
- Burnier L., Lanini M., Bouvard O., Scanferla D., Varathan A., Genoud C., Marguerit A., Cuttat B., Dury N., Witte R., Salvade A., Schueler A., Energy saving glazing with a wide band-pass FSS allowing mobile communication: up-scaling and characterisation, in IET Microwaves Antennas & Propagation, vol. 11, num. 10, p.1449-1455, 2017
- Vitale W. A ., Casu E. A ., Biswas A., Rosca T., Alper C., Krammer A., Luong G. V., Zhao Q.-T ., Mantl S., Schüler A., Ionescu A . M ., A Steep-Slope Transistor Combining Phase-Change and Band-to-Band-Tunneling to Achieve a sub-Unity Body Factor, in Scientific Reports, vol. 7, num. 1, 2017
- Oliva N., Casu E. A., Yan C., Krammer A., Rosca T., Magrez A., Stolichnov I., Schueler A., Martin O.J. F., Ionescu A. M., Van der Waals MoS2/VO2 heterostructure junction with tunable rectifier behavior and efficient photoresponse, in Scientific Reports, vol. 7, num. 1, p.2923-2929, 2017

Patents

- WO2017134589 A1: Coating for optical and electronic applications
- EP2882921: Glazing with embedded microstructures for daylighting and seasonal thermal control
- WO 2014045141 A2: Laminated glazing with coloured reflection and high solar transmittance suitable for solar energy systems
- WO 2014045144 A1: Interference filter with angular independent orange colour of reflection and high solar transmittance, suitable for roof-integration of solar energy systems